LOTZ

Report upon a
Highway Bridge

Civil Engineering
B. S.

1901

UNIVERSITY
OF
ILL. LIBRARY

Learning and Labor.
LIBRARY
OF THE
University of Illinois.
CLASS. BOOK. VOLUME.
1901 L91
Accession No.

Digitized by the Internet Archive
in 2013

http://archive.org/details/reportuponhighwa00lotz

LIBRARY
UNIV. OF ILL.
URBANA

204
U6R

REPORT

UPON A

HIGHWAY BRIDGE

BY

JOHN RUDOLPH LOTZ

THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE

IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1901

LIBRARY
UNIV. OF ILL.
URBANA

UNIVERSITY OF ILLINOIS

May 29, 1901 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

John Rudolph Lotz

ENTITLED Report on a Highway Bridge

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering.

REPORT UPON A HIGHWAY BRIDGE

On the selection of a thesis subject, it is the writer's belief that the student should be guided by a desire to choose one which will afford experience in the practical work an engineer is called upon to do. The investigation of, and report upon, an existing engineering structure seemed to present such a problem. A bridge was chosen because the course in civil engineering best fits the student for an intelligent report upon a structure of this kind. It was thought that the necessary field inspection, as well as the detailed investigation, would greatly enhance the knowledge of good and bad design gained in the class room.

It is proposed to make a report upon an iron highway bridge, built by the La Fayette Bridge Company, spanning the Vermilion River at Danville, Illinois, and known as "The Woolen Mill Bridge". This particular bridge was chosen because of the various types of construction

53402

embodied and because of its proximity to the University. A minor reason for the selection was that apparently the structure was of poor design and it was thought that an investigation of these features would not be without interest and instruction. An engineer in practice is required not only to build new structures of good design but also to report upon old structures of poor design.

The report will be presented in the form which would be required of an assistant engineer by his superior.

THE REPORT

On March twenty third nineteen hundred and one, I, with Mr. B. W. Sticks as assistant, and recorder, visited the bridge commonly known as "The Woolen Mill Bridge" at Danville, Illinois, and inspected the same pursuant to your order. Such measurements were taken as would permit an accurate determination of the dead load and the efficiency of all members. Careful note was made of the condition of all details, the stability of the

masonry piers, evidences of weakness, and the character of the traffic over the bridge.

The investigation will be made under Waddell's Specifications for Highway Bridges, (Edition 1889)

The structure is shown in outline in Fig. 1. The west approach is a viaduct

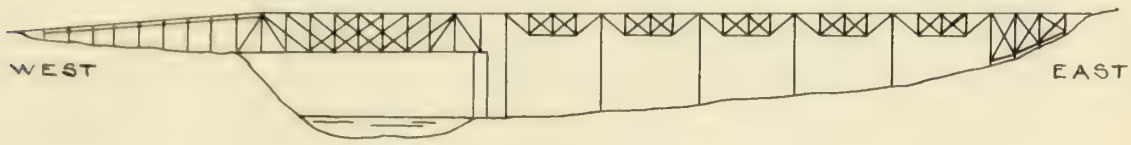

Fig. 1.

of nine trestle bents having iron posts. The panels are 17 feet 6 inches long. The channel span is a Whipple or "double intersection" deck bridge of ten panels, each 17 feet 3 inches long. The east approach consists of five deck Pratt trusses of four panels each 17½ feet long, resting upon iron posts; and four trestle bents each 17½ feet long, resting upon iron posts. The roadway on the west approach has a grade of 3%, and on the remainder of the bridge it is level. The roadway is 17 feet wide and there are two 4½ foot sidewalks. The floor beams are built-up sections.

The joists are of 3" x 12" oak, spaced 2 feet c to c. A lattice fence runs the entire length of the bridge

All trestle posts and the west pedestals of the river span rest upon sandstone piers. The east pedestals of the river span rest upon two iron cylinders, filled with concrete. The cylinders are braced by lateral ties and struts. All structural metal is Clinton wrought iron.

I-MAIN OR RIVER SPAN

MAIN TRUSSES. The depth is 25 feet, the panel length 17⅓ feet, and the driveway 17 feet with a 4½ foot sidewalk on either side.

From a careful computation of the weight, the dead load was found to be 900 pounds per foot of bridge. Hence the dead load per panel per truss is 7,760 pounds.

The bridge was built to connect the business portion of the city with the brick yards and coal mines west of the river, hence it is subject to heavy traffic.

The live load will be assumed as 100 pounds per square foot of roadway* The live

* Herein is an error since the specifications require 90 lbs. for this span.

load per panel for truss then is 22,425 pounds.

The stresses, in tons, for one elementary truss are shown in Fig. 2, and for the other elementary truss in Fig. 3. Fig. 4 gives the stresses for the two elementary trusses combined.

STRESSES IN THE ELEMENTARY TRUSSES

DUE TO LIVE AND DEAD LOAD

Results are in tons

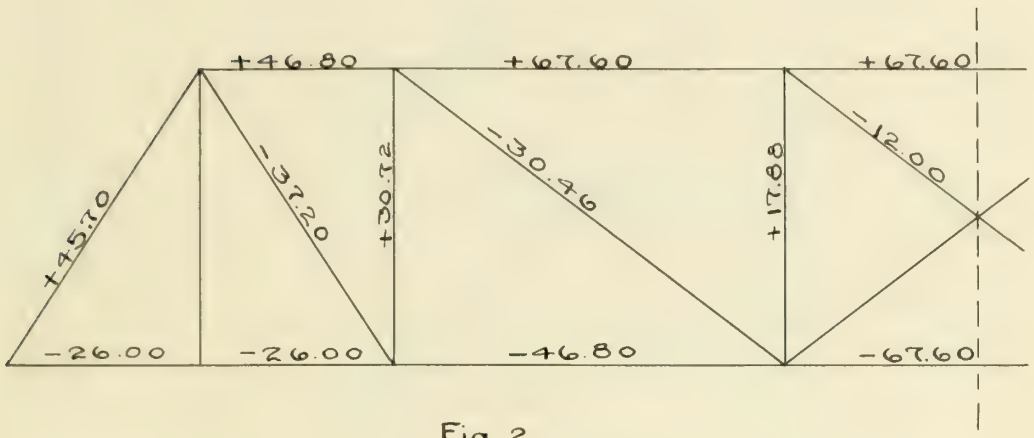

Fig. 2.

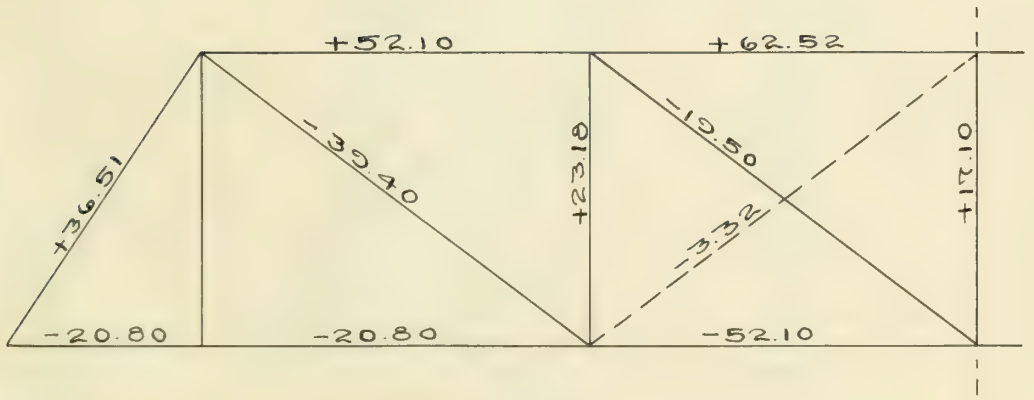

Fig 3.

MAXIMUM STRESSES, SECTIONS, AND EFFICIENCIES OF MAIN TRUSSES

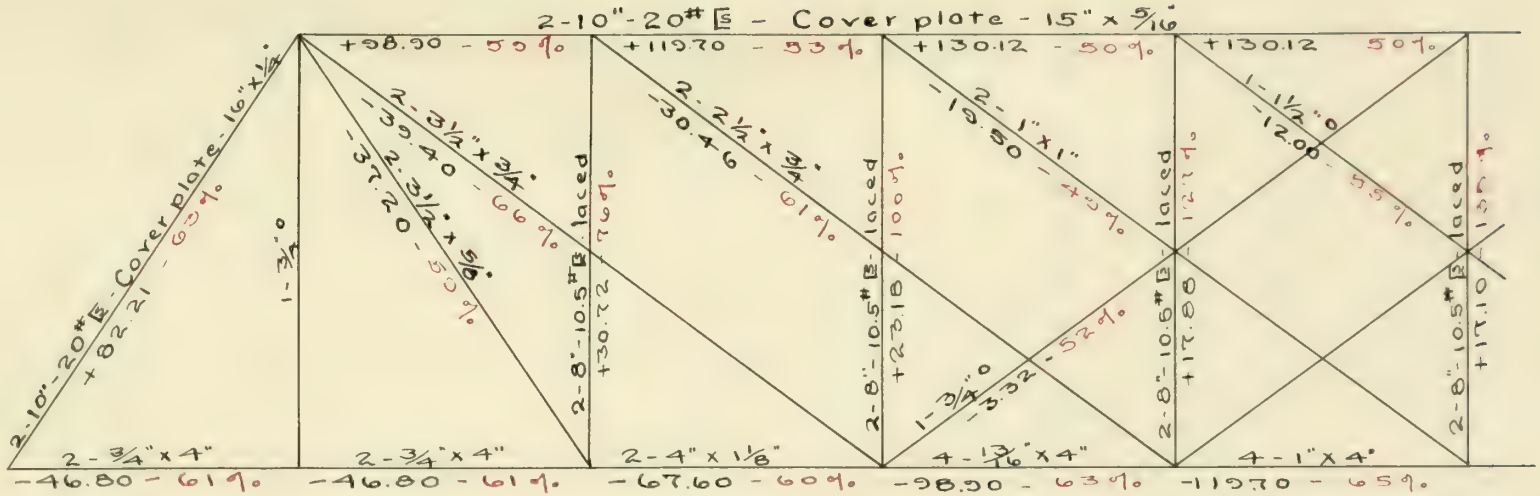

Fig. 4.

Fig. 4 also shows the sections of the main members of the river span. The red figures show the per cent of efficiency of the several members, that is, the red figures show the capacities of the pieces in per cents of the strength required by the specifications. A bridge that would fully meet the specifications would have an efficiency of at least 100 % in all its members. It will be noticed that the efficiencies of the members in Fig. 4 range between 30 and 60 %.

Undoubtedly the trusses were not designed to carry the live load used in the above calculations. It is possible that the bridge may never be subjected to the assumed live load. Under the specifications for a Class A bridge, the permissible live load is only 32 pounds per square foot of bridge, or 36 % of the live load required for Class A bridges. Under the specifications for Class C bridges, which it is stated are those for ordinarily light traffic, - for ordinary country roads, the safe load is but 43 pounds per square foot of bridge or 57 % of the load required for Class C bridges. The traffic over this bridge is certainly not light nor that of country roads. The trusses

are probably strong enough for the usual loads brought upon them. Heavy loads of coal, bricks, and sand are constantly passing, but this traffic will probably never become congested sufficiently to raise the live load above the safe amount. Probably the only load which would be dangerous is a crowd of people upon the bridge. The location, at a point where holiday river sports might take place, makes it necessary to provide for this loading. Therefore the writer believes that the span should be removed and replaced by a bridge designed as a Class A structure.

Strictly speaking a report to the chief engineer would end here. The object of the thesis, however, is a detailed investigation so a further report will be submitted.

THE PINS. All the chord pins are 3¾ inches in diameter except the one at the foot of the hip vertical. The stress in the last mentioned pin is only nominal. From a study of the arrangement of the pieces on the pins, it was concluded that the center pin of the lower chord had the maximum stress. The maximum bending moment on this pin was found to be 123,200 inch pounds. The rat-

lowable bending moment is 103,540 inch-pounds. Therefore the efficiency of the pin is 83%, — 13% stronger than the strongest bridge member attached to it.

The efficiency of the pins for bearing is in no case less than 90%.

THE RIVETING. In only one case is the efficiency of the riveting less than 100% and that is in the top chord splice. There are three field rivets and three bolts in each channel, and eight field rivets in the cover plate splice. The bolts are loose in the holes. The field rivets will carry only 35% of the stress in the member. The channels and plate are spliced in the same plane and all the pieces have a good butting contact, and therefore the splice conforms to the requirements of good practice.

LOWER LATERAL SYSTEM. The wind load on the unloaded chord is assumed as 150 pounds per foot of bridge.

The sections, stresses, and efficiencies of the members are shown in Fig. 5.

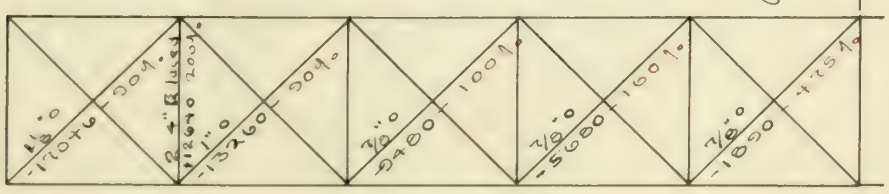

Fig. 5.

The sections are satisfactory. All lateral rods are hurt at the ends. This is contrary to the specifications and to good practice. The struts are fastened to the lower chord pins by a stirrup as shown in Fig. 6. There is no evidence of a tendency to buckle and, since no wind is carried down the intermediate posts from the loaded chord, this is probably strong enough.

Although the connection is sufficient for this case it is a poor design.

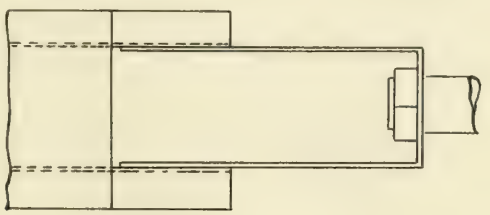

Fig. 6.

TOP LATERAL SYSTEM. The wind load on the loaded chord is assumed as 250 pounds per foot of bridge.

The sections, stresses, and efficiencies of the members are shown in Fig. 7.

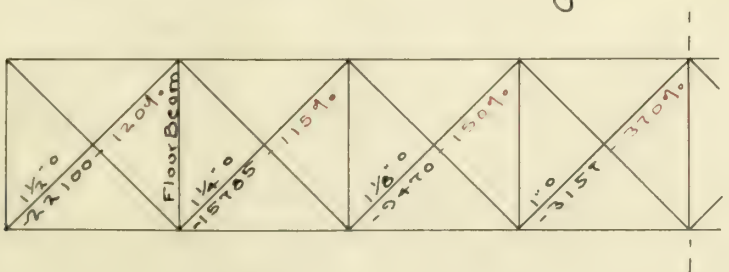

Fig. 7.

The sections are sufficient. The rods have butt eyes as in the lower lateral system.

SWAY BRACING. The sway bracing at each panel consists of two 7/8-inch round rods but at the ends. These rods have an efficiency of 127% for the greatest wind load which may come upon them and hence, except for the butt ends, are more than sufficiently strong.

PORTAL SYSTEM. The form of the portal system is shown in Fig 8, which also shows the stresses, sections, and efficiencies of the members.

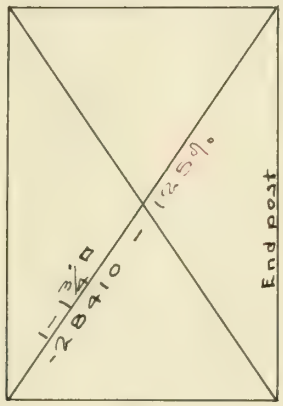

Fig. 8.

The portal is entirely satisfactory.

THE PEDESTAL. There are nine rollers, each two inches in diameter and two feet long. The efficiency of the rollers for the greatest load which may be brought upon them is 120%.

The action of the rollers is effectually prevented by the great amount of soil which has collected about the pedestal, the entire top of the pier being covered

Both the thickness of the shoe plate and the pressure upon the masonry are within the requirements of the specifications.

FLOOR BEAMS. The form of the floor beam is shown in Fig. 9.

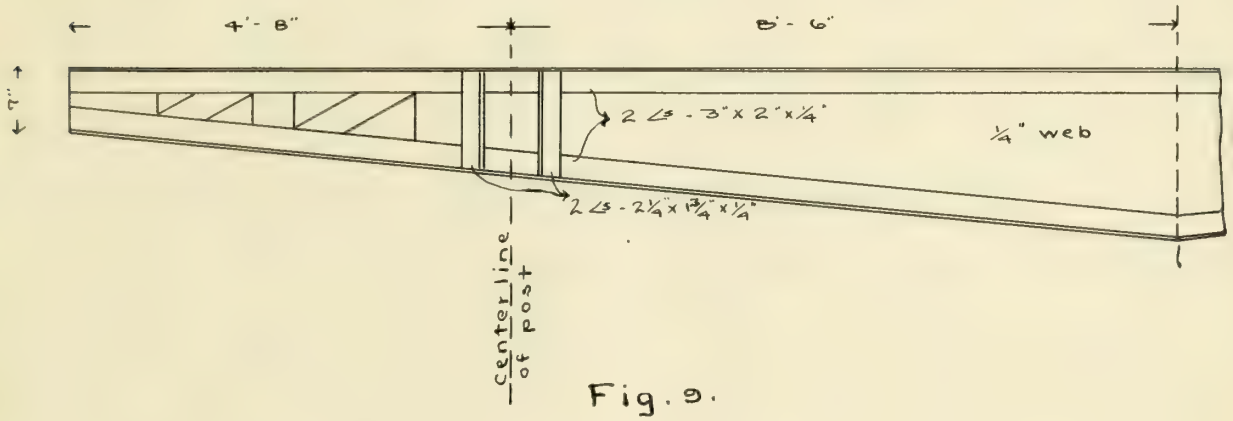

Fig. 9.

The efficiency of the beam for bending, when subjected to a live load of 100 pounds per square foot of clear roadway, is only 27%. The efficiency of the beam for shear when subjected to this load is 76%. The beam has only 31½% of the required strength for a loading of 80 pounds per square foot. The safe load, that is, the load which will give the beam an efficiency of 100% under the specifications, is only 44 pounds per square foot. A record of

people on the bridge might easily raise the load for any one floor beam, to 50 pounds per square foot. A heavy traction engine may produce a load equivalent to 51 pounds per square foot of bridge.

Even though the joists may be found to be strong enough, the very apparent weakness of the floorbeams makes it necessary to condemn the floor system as unsafe.

THE JOISTS. Considering the joists as sound white oak, the efficiency for dead and live load is 70%. A heavy traction engine, supported by four joists, will reduce the efficiency to 65%. So many of the joists are badly decayed, it is difficult to state what load they will safely carry. Some of the pieces are broken and entirely useless.

II THE APPROACHES

THE TRUSSES. The dead load was found to be 350 pounds per foot per truss. Therefore the panel load per truss is 6,125 pounds.

The live load will be considered the same as for the main span, 100 pounds per square foot of roadway, or a panel load of 22,750 pounds.

The stresses in tons, and the sections of the members are shown in Fig 10. The red figures indicate the efficiencies of the members.

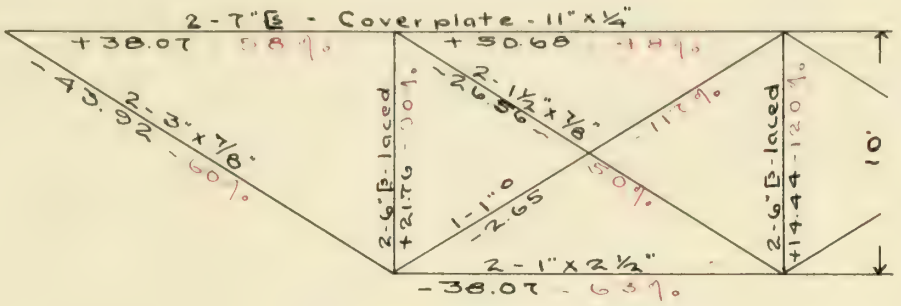

Fig. 10.

An examination of Fig. 10 shows the efficiencies of the members to range between 48 and 63%. The same criticism which was made concerning the main span, applies to this truss. The writer would condemn the truss as unsafe.

THE PINS. Both the middle and end pins of the lower chord were examined and their efficiencies found to be 93 and 80% respectively.

The pins are stronger than the average member attached to them.

The bearing on the pins is in no case greater than that allowed by the specifications.

THE RIVETING. The riveting is better than

that in the main span. The field rivets in the top chord splice give the joint an efficiency of 45%, and all pieces are in good butting contact.

LATERAL SYSTEMS. The lateral system sections are excessive. The systems were evidently designed to meet the requirements for minimum sections of the specifications under which the bridge was built.

All the lateral rods have bent eyes, a connection which, as has been stated, is contrary to the specifications, and to good practice. The struts are connected to the main trusses by the stirrup discussed under the channel span.

PORTAL, AND SWAY BRACING. These systems are satisfactory.

FLOOR SYSTEM. The floor system is the same as that for the channel span, and since the panel length is practically the same no further report will be made.

III - THE TRESTLE POSTS

EAST APPROACH. The stresses, sections, and the efficiencies of the members of the highest bent, one of those which support the

trusses, are shown in Fig. 11.

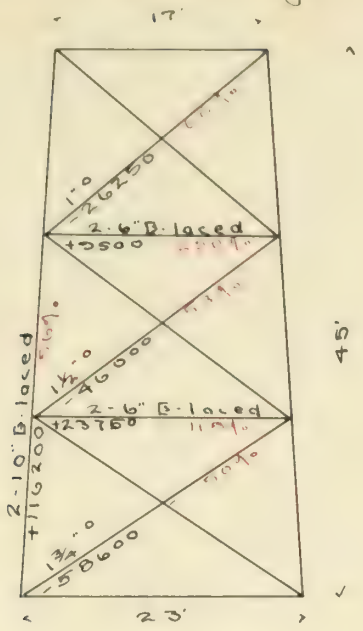

Fig. 11.

The safe live load for the posts, that is, the load which will give them an efficiency of 100 %, is only 22 pounds per square foot of roadway, or 22 % of the load required for class A structures.

The overturning moment of the wind is equal to 855,000 foot pounds. The resisting moment of the weight is equal to 616,300 foot pounds, or the resisting moment is equal to only 72 % of the wind moment. This efficiency is much greater than that for more important parts of the bridge and, besides, the above computations take no account of the resistance of the anchorage.

WEST APPROACH. The stresses, sections, and efficiencies of the highest unit of the west

approach are shown in Fig. 12.

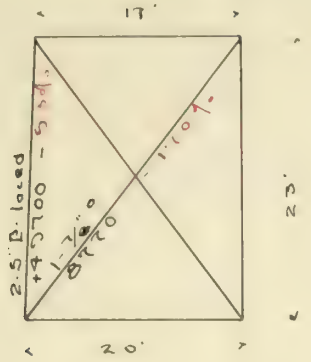

Fig. 12.

The safe live load for the posts is 50 pounds per square foot of roadway.

IV - THE MASONRY PIERS

All the piers are of squared sandstone masonry, and, with one exception, are in excellent condition. The second pier from the east end on the south side is badly cracked. There is no evidence of settlement but the foundation is not considered safe. All the piers under the east approach extend above the ground while those under the west approach have become entirely covered with soil.

The bearing on the masonry in no case exceeds that allowed under the specifications.

V-THE TUBULAR PIERS

The iron cylinders appear to be in excellent condition. Careful observation revealed no evidence of weakness.

SUMMARY

The flooring is almost worn out. The joists, floorbeams, trusses, and posts have but a small percent of the strength required by the specifications, even for country highway bridges. Therefor I recommend that the entire structure be removed and replaced by a Class A bridge.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 086855092